Practice Problems and Chapter and Unit Review Problems

Chapter 1

Practice Problems

1. 9.6×10^{-13} N
2. 9.3 m/s
3. 0.61 m/s^2
4. (a) 0.249 N (b) 0.00127
5. 78 N
6. (a) 58 N (b) 16 m/s^{-2}
7. 6.7 m
8. 1.6×10^3 N, 9.1×10^2 N
9. (a) 21 N (b) 15 N
10. (a) 74 N (b) 34 N
11. negative; 5.9×10^2 N
12. down (negative); 6.9×10^2 N
13. up (positive); 5.9×10^2 N
14. –1.9 m/s^2
15. No, the climber must limit his descent to $a = -2.5$ m/s^2.
16. (a) downward (b) –1.1 m/s^2 (c) 87 N
17. 1.7×10^2 N
18. 1.8 m/s^2
19. 0.49 m/s^2; 39 N
20. 14 kg; 75 N
21. 62 kg; 1.6 m/s^2
22. 17 N
23. Both of them will rise, with $a = +1.0$ m/s^2.
24. (a) 3.88 N (b) 2.04 m/s^2
25. 0.67 s
26. 15 m/s
27. (a) 1.2 m/s^2 (b) 0.16 m/s^2 (c) 12 s
28. 0.061
29. 0.34 m
30. 0.37

Chapter 1 Review

Problems for Understanding

16. 3.0 m/s[N]
17. 11 kg
18. (a) $v = 0$; $a = -9.8$ m/s^2
(b) 3.5 m/s; –9.8 m/s^2
19. (a) 1.34 m/s^2 (b) 334 N
20. 1.1 m/s^2[W]
21. 1.2 N
22. (a) 0.062 m/s^2
(b) 0.40 m/s^2
(c) A friction force of magnitude 3.4 N operates to reduce the ideal acceleration ($a = F/m$)
23. 5.4 m
24. 11 m
25. (a) 5.4 m/s[down]
(b) 3.8×10^4 N[up]
26. 49 N
27. 1.3 m/s^2
28. (a) $a_2 = 2.5a_1$ (b) $d_2 = 2.5d_1$
29. (a) 9.00 N (b) 132 N (c) 293 N (d) 0.451
30. 3.3 m/s^2; 13 N
31. (a) 4.6 m/s^2 (b) 0.70 N

Chapter 2

Practice Problems

1. –677 m
2. 4.67 m/s
3. 89.6 m, 45.2 m/s [60.3° below the horizontal]
4. 0.156 m
5. 3.05 m/s
6. 0.55 m
7. 74 m
8. (a) 153 m (b) 5.00 m/s
9. 85 m
10. 4.0×10^1 m
11. 18 m/s [52° below the horizontal]
12. 2.8 m/s
13. (a) 58.9 m (b) 21.0 m (c) 4.14 s
14. 33.2°; 2.39 m; 1.40 s
15. 47.0 m/s
16. 8.3×10^{-8} N
17. (a) 48.6 N (b) 54.2 N (c) 9.62 m/s
18. 5.9×10^3 N
19. 84 m
20. 103 m
21. 13 m/s (47 km/h)
22. 19.1 m/s (68.8 km/h)
23. 20.1°

Chapter 2 Review

Problems for Understanding

20. (a) 3.0×10^1 m (b) 3.7 s
21. (a) 0.78 s
(b) at the same position
(c) 4.7 m (d) 9.7 m/s
22. (a) 42 m (b) 62 m
23. 2.7×10^2 m
24. (a) 2.1 s (b) 34 m
(c) 8.5 m
(d) $v_x = 16$ m/s; $v_y = +3.8$ m/s or –3.8 m/s
(e) 38.2°
25. 52 m/s
26. Yes. It travels 330 m.
27. (a) 7.4 s
(b) 67 m
(c) 1.2×10^2 m
(d) x: 34 m, y: 53 m
(e) $v_x = 17$ m/s; $v_y = -23$ m/s
28. (a) 193 m/s
(b) 843 m
(c) $v_x = 162$ m/s, $v_y = 156.3$ m/s
(d) 44.0°
29. (a) 2.0 m/s (b) 1.2 m/s^2
30. 7.1×10^2 N
31. (a) 1.33×10^{14} m/s^2
(b) 1.21×10^{-16} N
32. 0.33
33. 8.9 m/s
34. 33°
35. (a) 9.90 m/s
(b) A factor of $\sqrt{2}$
36. 0.62
37. (a) 4.6×10^2 m/s
(b) 2.0 N (for $m = 60.0$ kg)
(c) Toward the centre of Earth; gravity
(d) $mg = 589$ N (for $m = 60.0$ kg)
(e) $N = mg - mv^2/r = 587$ N
(f) $mg - N = ma_c$; because $mg > N$, there is a net acceleration toward the centre of Earth.

Chapter 3

Practice Problems

1. 3.57×10^{22} N
2. 1.99×10^{20} N
3. 5.1×10^{-3} m. This is much smaller than the radii of the bowling balls.
4. 3.61×10^{-47} N
5. 5.0×10^{24} kg
6. 0.25 m
7. $F_{Uranus} = 0.80 \times F_{Earth}$
8. 0.9 × Earth-Moon distance
9. 1.899×10^{27} kg
10. 1.472×10^{22} kg
11. 2.74×10^5 m
12. 1.02×10^3 m/s
13. (a) 6.18×10^4 s (17.2 h)
(b) 7.93×10^2 m/s
14. 4×10^{41} kg $= 2 \times 10^{11} \times M_{Sun}$

15. 7.42×10^3 m/s; 8.59×10^5 m

16. 7.77×10^3 m/s; 5.34×10^3 s (89.0 min)

17. (a) 5.21×10^9 s (165 years); 5.43×10^3 m/s
(b) It will complete one orbit, after its discovery, in the year 2011.

Chapter 3 Review

Problems for Understanding

22. 1/8

23. (c) F

24. (b) $a/3$

25. (a) 3.0×10^4 m/s
(b) 6.0×10^{-3} m/s^2

26. 1.8×10^{-8} m/s^{-2}

27. 9.03 m/s^2 = 92% of acceleration due to gravity at Earth's surface

28. 4.1×10^{36} kg = $2.0 \times 10^6 \times m_{Sun}$

29. 2.67×10^{-10} N

30. (a) 5.3×10^5 m
(b) 5.7×10^3 s = 95 min

31. 1.02×10^3 m/s; 2.37×10^6 s = 27.4 days

32. (a) Yes.
(b) 5.69×10^{26} kg

33. (a) 4×10^{15} kg
(b) 4×10^{27} kg
(c) $m_{Oort} = 700 m_{Earth} = 2 m_{Jupiter}$

Unit 1 Review

Problems for Understanding

29. 1.4 m/s^2

30. (a) 2.00 **(b)** 2.00

31. 1.6×10^4 N. The acceleration remains constant.

32. (a) 3.1×10^3 N **(b)** 4.5 m

33. 1.1×10^4 N

34. (a) 7.00×10^3 N **(b)** 9.16 × true

35. (a) 1.5×10^4 N
(b) 3.8×10^3 N
(c) 2.5 m/s^2
(d) 22 m/s = 81 km/h
(e) 9.0 s

36. 17°

37. (a) 9.8×10^2 N **(b)** 13 km

38. 3.3 m/s^2; 23 N

39. (a) 1.4 s **(c)** 5.0×10^1 m
(b) 1.8 s

40. (a) 21.3 m/s **(c)** down
(b) 1.54 m

41. 2.40 m

42. 0.084 m

43. (a) 4.4×10^2 N; 1.0 × her weight
(b) 2.0×10^2 N; 0.45 × her weight
(c) same as (a)
(d) 6.8×10^2 N; 1.6 × her weight

44. 2.0×10^2 N

45. (a) 6.9×10^3 N **(b)** 64 km/h

46. (a) 612 N **(c)** 786 N
(b) 437 N **(d)** 612 N

47. 29 m/s^2

48. (a) 5.1×10^2 N **(b)** 5.6×10^2 N

49. (a) 1.7×10^2 N **(b)** 29 m/s

50. (a) 8.0 m/s^2
(b) 6.9 m/s^2
(c) 6.0×10^1 m/s[down]; 52 m/s[down]

51. (a) 0 m/s^2; 2.0×10^1 N
(b) 2.0 m/s^2; 16 N
(c) 0.50

52. 2.4 m/s^2; 0.61 m/s^2

53. Swift-Tuttle: **(a)** 51.69 AU; **(b)** 26.32 AU; **(c)** 135.5 a
Hale-Bopp: **(a)** 369.2 AU; **(b)** 185.1 AU; **(c)** 2511 a
Encke: **(a)** 4.096 AU; **(b)** 2.218 AU; **(c)** 3.303 a
Kopff: **(a)** 5.351 AU; **(b)** 3.467 AU; **(c)** 6.456 a
Hyakutake: **(a)** 1918 AU; **(b)** 959.1 AU; **(c)** 2.970×10^4 a
(d) student sketch
(e) Swift-Tuttle, Hale-Bopp, and Hyakutake

54. (a) 4.6×10^2 m/s
(b) 7.9×10^3 m/s

55. (a) 0.7445 AU **(c)** 1.732 a
(b) 1.442 AU

56. 2×10^{42} kg; 1×10^{12} m_{Sun}

Chapter 4

Practice Problems

1. (a) 11.5 kg m/s[E]
(b) 2.6×10^8 kg m/s[W]
(c) 8.39×10^7 kg m/s[S]
(d) 5.88×10^{-24} kg m/s[N]

2. 43.6 N s[down]

3. 2.58×10^5 N · s[S]

4. 4.52×10^6 N[S]

5. 2.6 kg m/s[horizontal]

6. –38 kg m/s

7. 8.8 kg m/s[up]

8. 2.7 m/s[in the original direction]

9. 0.11 m/s[in the direction that car A was travelling]

10. 2.10 m/s[S]

11. 0.11 m/s[E]

12. -2.43×10^2 m/s

13. 6.4 m/s[40.0° counterclockwise]

14. 1.16 m/s[6.1° clockwise from original direction]

15. v_A = 34.3 km/h[S]; v_B = 67.3 km/h[E]

16. v_2 = 6.32 m/s[41.5° counterclockwise from the original direction of the first ball]; the collision is not elastic: E_k = 12.1 J; E_k' = 10.2 J.

17. 1.24×10^5 kg km/h = 3.44×10^4 kg m/s[N39.5°W]; the collision was not elastic: $E_k = 3.60 \times 10^6$ kg km^2/h^2; $E_k' = 1.80 \times 10^6$ kg km^2/h^2

18. 261 m/s

19. The cart will stop at 0.018 m; therefore, it will not reach the end of the track.

20. 55.5 km/h = 15.4 m/s

21. 18.2 m/s

22. 3.62 m/s; 1.71 m

Chapter 4 Review

Problems for Understanding

28. 18 kg m/s[N]

29. 1.5×10^3 kg

30. 1.20 m/s[S]

31. 6.0×10^3 m/s[forward]

32. (a) 0.023 N · s[E]
(b) 0.036 N · s[S]

33. 3.8×10^3 N

34. 3.6×10^{-2} s

35. (a) –16 kg m/s
(b) 6.4×10^{-3} s

36. 2.5×10^4 N[E]

37. 2.9×10^4 N

38. 134 m/s[E]

39. 3.1 m/s[E]

40. –2.3 m/s

41. 1.3 m/s[forward]

42. 0.17 m/s[forward]

43. 4.4 m/s[35.2° clockwise]

44. 5.6×10^6 m/s[26.6° with respect to the +x direction]

45. (b) **(i)** $v_1' = -v_1$; $v_2' \approx 0$;
(ii) $v_1' \approx 0$; $v_2' = v_1$;
(iii) $v_1' = v_1$; $v_2' = 2v_1$
(c) (i) is the limiting case of a small object hitting a wall: it bounces back with the same speed and opposite direction. In (ii), all of the momentum is transferred to the other particle. In (iii), the massive object continues as if the light object had not been there, while the light object flies off with twice the speed of the massive object.

46. $v_1' = 0.86$ m/s[S]; $v_2' = 1.25$ m/s[N]. In a perfectly elastic head-on collision between identical masses, the two bodies simply exchange velocities.

47. (a) 0.29 m/s[W21°N]
(b) 70%

48. (a) 0.21 m/s (c) 95%
(b) 13 kg m/s

Chapter 5

Practice Problems

1. 1.810×10^4 J
2. 1.22×10^4 m
3. 31.5°
4. 61.6 m
5. 34.6 m/s
6. -2.6×10^2 N
7. 515 kg
8. 15.0 m
9. 4.9×10^{-2} J
10. 13 m/s
11. 7.7 m
12. 4.8 m
13. 0.25 J
14. 250 J
15. $v_A = 2.0$ m/s; $v_B = 2.8$ m/s
16. 5×10^2 N/m
17. (a) 0.414 m (b) −455 N
18. 0.0153 kg
19. 1.0 J
20. 0.30 m
21. 1.4 J
22. (a) 0.28 m (b) 1.3 m/s
(c) $17 m/s^2$
23. 1.4×10^3 N/m
24. 6.59×10^3 N/m
25. 0.42 m
26. (a) 405 N/m (b) $44.1 m/s^2$
27. 11 m/s
28. 14 m/s
29. 7.4×10^2 J

Chapter 5 Review

Problems for Understanding

18. (a) 0.035 N (c) 0.025 J
(b) −0.025 J
19. (a) 16 J (b) 16 J
20. (a) 7.7×10^3 J
(b) 6.7×10^3 J
(c) 9.4 m/s; 8.7 m/s
(d) infinity (no friction); 1.3×10^2 m
21. 3.2×10^2 N · m
22. (a) 9.0 m/s
(b) $E_k = W = 2750$ J (2.8×10^3 J)
(c) 4.1 m
23. 57 N
24. 4.6 m/s
25. 4.5×10^2 N/m
26. (a) 0.38 J (b) 9.6 N
27. 0.19 m
28. $k = m_1g/x$
29. 3.6 m/s
30. 4.1°C
31. 0.28°C
32. (a) 2.3 m/s (b) 5.3 N
33. 1.3 m/s
34. 0.77 m/s; 0.031 m
35. 5.0 m/s
36. 0.15 m
37. 0.45 m
38. 0.096 m
39. (a) -8.7×10^2 J (b) −1.8 m

Chapter 6

Practice Problems

1. 4.0×10^6 J; 1.16×10^3 m/s
2. 1.9×10^5 J; 5.0×10^3 m/s
3. 1.85×10^4 m/s
4. (a) 1.5×10^9 J (c) -1.5×10^9 J
(b) -3.0×10^9 J (d) 1.5×10^9 J
5. (a) 3.32×10^9 J (c) 7.51×10^6 m
(b) 7.29×10^3 m/s
6. (a) 4.12×10^9 J
(b) thermal energy, acoustic energy
7. 1.57×10^3 m/s; 649 m/s
8. (a) 4.87×10^7 J; 1.27×10^3 m/s
(b) -9.74×10^7 J (d) 4.87×10^7 J
(c) -4.87×10^7 J (e) 528 m/s
9. (a) 1.7×10^8 J; 1.8×10^3 m/s
(b) -3.4×10^8 J (d) 1.7×10^8 J
(c) -1.7×10^8 J (e) 7.7×10^2 m/s
10. 1.4×10^{31} kg, or 7.1 times the mass of the Sun
11. 6.00×10^6 N[forward]
12. 5.01×10^3 kg/s
13. (a) 0.33 m/s; 0.69 m/s; 1.1 m/s; 1.5 m/s; 1.9 m/s; 2.4 m/s
(b) 3.0 m/s, a difference of 0.6 m/s. Throwing all of the boxes at once contributes more to the momentum of the cart, because the cart is lighter without the boxes on it.

Chapter 6 Review

Problems for Understanding

14. 3.13×10^9 J
15. (a) 1.1×10^{11} J (b) 39%
16. -1.78×10^{32} J
17. $0.488 \times v_{Earth}$
18. (a) 6.18×10^5 m/s
(b) 4.22×10^4 m/s
(c) 6.71×10^3 m/s
19. (a) 7.0×10^7 m (b) 650 km
20. (a) 1.6×10^2 m/s. No.
(b) 1.2×10^2 m/s. No.
(c) 12 m/s. Yes.
(d) 2.9×10^8 m/s. No — in fact, the poor pitcher would be crushed by the strong gravity before he could even wind up for the throw!
21. 11.1 km/s; 99.4% of Earth's escape speed
22. 7.9×10^{11} m. This is just past Jupiter's orbit.
23. (a) -4.1×10^{10} J (c) 3.7×10^{10} J
(b) -3.1×10^9 J (d) 3.1×10^9 J
24. (a) $v_{200} = 7.78 \times 10^3$ m/s; $v_{100} = 7.84 \times 10^3$ m/s
(b) $E(r = 200 \text{ km}) = -1.52 \times 10^{10}$ J; $E(r = 100 \text{ km}) = -1.54 \times 10^{10}$ J
25. (a) 2.3×10^7 m/s; $0.077c$
(b) 0.14 s
26. 4.89×10^6 kg
27. (a) 3.4×10^6 N (b) 1.2×10^5 m/s

Unit 2 Review

Problems for Understanding

37. 3.5×10^4 kg m/s[N]
38. (a) 6.6 kg m/s
(b) 4.0×10^1 kg m/s
(c) 3.0×10^3 kg m/s
39. (a) 9.6 kg m/s[N]
(b) −17 kg m/s[N]
(c) 17 kg m/s[S]
(d) 2.6×10^2 N[N]
(e) 2.6×10^2 N[S]
40. (a) 45 N (b) 42 m/s
41. 36 m/s
42. (a) 1.3×10^4 kg m/s
(b) -1.3×10^4 kg m/s
(c) -1.3×10^4 kg m/s
(d) 19 m/s
43. 2.6×10^2 m/s[forward]
44. 1.5 m/s[N27°E]
45. (a) 0.76 m/s[E24°N]
(b) 17%

46. (a) 780 J
(b) It loses 780 J.

47. (a) 3×10^{11} J **(b)** 5 GW

48. (a) 66 m
(b) 74 m
(c) No change; the result is independent of mass.

49. -7.9×10^3 N

50. (a) 0.24 J **(b)** 48 J

51. (a) 0.32 m **(b)** 12 J

52. 15 kg

53. 60.0 m

54. (a) 1.46×10^4 J
(b) 1.46×10^4 J; 12.5 m/s
(c) Needed: coefficient of friction, μ, and slope of hill, θ: $E_k = mgh(1 - \mu/\tan\theta)$; $v = \sqrt{2gh(1 - \mu/\tan\theta)}$. For $\mu = 0.45$ and $\theta = 30.0°$, $E_k = 3.2 \times 10^3$ J, $v = 5.9$ m/s.

55. 3.1 m/s

56. (a) 0.47 m **(b)** 0.47 m

57. (a) 6.0 N **(c)** 0.023 J
(b) 0.15 J

58. 1.16×10^3 J. No, work is done by friction forces.

59. (a) 4.4 m/s **(b)** 3.5 m/s

60. (a) 11.2 km/s
(b) 7.91 km/s
(c) 6×10^{10} m or 10 000 Earth radii

61. 7.3×10^3 m/s

62. At Earth's distance from the Sun, the escape velocity is 42 km/s. Thus, the first comet is bound (it has negative total energy) and the second one is not bound (it has positive total energy).

63. 4.2×10^3 m/s; 1.0×10^4 m/s

64. 6.8 km/s; 15 km/s

65. (a) 1.3×10^{10} J
(b) -1.3×10^{10} J
(c) 6.1×10^3 J
(d) 1.3×10^{10} J
(e) 2.2×10^9 J; 3.1 km/s

66. (a) -7.64×10^{28} J
(b) -5.33×10^{33} J

67. 6.2×10^5 m/s

68. 2.6×10^2 m/s[forward]

Chapter 7

Practice Problems

1. 0.34 N

2. 0.80 m

3. 5.1×10^{-7} C

4. 0.50 N

5. 0.17 N (repulsive)

6. 0.12 m (directly above the first proton)

7. $F_A = 1.2 \times 10^{-2}$ N[W73°S]; $F_B = 1.6 \times 10^{-2}$ N[E63°N]; $F_C = 4.6 \times 10^{-3}$ N[W36°S]

8. 8.74 N[E18.2°N]

9. 2.0×10^{-8} C

10. 7.9×10^{-8} C

11. 1.5×10^5 N/C (to the right)

12. 0.019 N[W]

13. 2.5×10^4 N/C (to the left)

14. -4.0×10^{-4} C

15. 3.8 N/kg

16. 52 N

17. 3.46 kg

18. 2.60 N/kg

19. 2.60 m/s^2

20. -7.8×10^5 N/C (toward the sphere)

21. -1.2×10^{-5} C

22. 0.32 m

23. 5.80×10^9 electrons

24. -1.5×10^6 N/C (toward the sphere)

25. 0.080 m

26. 5.3×10^8 N/C[81.4° above the $+x$-axis]

27. 1.9×10^4 N/C[86.7° above the $+x$-axis]

28. 3.4×10^6 N/C[23.7° above the $-x$-axis]

29. 2.25×10^{14} N/C (toward the negative charge)

30. 2.9×10^7 N/C[73.6° above the $+x$-axis]

31. 5.7×10^{-2} N/kg

32. 3.81×10^7 m

33. 8.09 N/kg

34. 5.82×10^{23} kg

35. 5.0×10^{-11} N/kg

36. 8.09 N/kg

37. 1.03×10^{26} kg

38. -4.7×10^{-2} J

39. 0.18 J

40. 5.1×10^2 m

41. 1.55×10^{-4} C. The signs of the two charges must be the same, either both positive or both negative.

42. 4.8×10^6 N/C

43. 1.5×10^{10} m

44. 2.9×10^{-5} J

45. -4.7×10^{-12} C

46. If the positive charge is placed at 0.0 cm and the negative charge is placed at 10.0 cm, there are two locations where the electric potential will be zero: 6.2 cm and 27 cm.

47. 1.1×10^6 V

48. 8.0 V

49. -2.1×10^6 V

50. 1.6×10^6 V

51. 1.4×10^{-6} C

52. 2.0 V

53. 12 J

54. -2.4×10^4 V

55. (a) 1.9×10^5 V
(b) 1.2×10^{-3} J
(c) A. It takes positive work to move a positive test charge to a higher potential. Since in this case, you invest positive work to move your positive test charge from B to A, A must be at a higher potential.

56. 5.3 cm and 16 cm to the right of the positive charge.

57. any point lying on a line midway between the two charges and perpendicular to the line that connects them

58. The potential is zero 3.4 cm above the origin and 24 cm below the origin.

59. If the distances of the first and second charges, q_1 and q_2, from the point of zero potential are d_1 and d_2, then d_2 must satisfy $d_2 = (-q_2/q_1)d_1$, with $q_2 < 0$. For example, if $q_2 = -8.0$ μC, then $d_2 = 16$ cm and the charge would be located either 24 cm to the right of q_1 or 8.0 cm to the left of q_1. Other solutions can be similarly determined.

60. 4.0 cm to the right of the -4.0 μC charge

Chapter 7 Review

Problems for Understanding

18. 9×10^3 N

19. 2.3×10^8 N

20. 5.6 cm

21. $F_A = 4.5 \times 10^{-2}$ N to the left; $F_B = 0.29$ N to the right; $F_C = 0.24$ N to the left

22. $F_A = 3.8$ N[N3.0°E]; $F_B = 4.4$ N[E23°S]; $F_C = 4.7$ N[W26°S]

23. $F_Q = 8.2 \times 10^{-8}$ N; $F_g = 3.6 \times 10^{-47}$ N

24. The charges on Earth (Q_E) and the Moon (Q_{Moon}) must satisfy

$|Q_E| \times |Q_M| = 3.3 \times 10^{27}$ C^2, and they must have opposite signs.

25. 4.2×10^{42}

26. -57 C

27. 5.2×10^{-3} N

28. **(a)** 8.65×10^{25} kg
(b) 8.81 N/kg
(c) 881 N

29. $2/9\ g_{Earth} = 2.18$ N/kg

30. **(a)** 8.24×10^{-8} N
(b) 2.19×10^{6} m/s
(c) 5.14×10^{11} N/C
(d) 27.2 V

31. 1.86×10^{-9} kg $= 2.04 \times 10^{21} \times m_{actual}$

32. 9×10^{-5} N[W]

33. 0.51 m

34. 6.0×10^{4} N/C[E37°N]

35. **(a)** -7.5×10^{-8} J
(b) It loses energy.

36. -2.9×10^{-6} J

37. 2.8×10^{2} C

38. **(a)** 4.5×10^{3} V
(b) Yes; the spheres have to be at equal potential, because the same point cannot have two different potentials.
(c) big sphere: 52 nC; small sphere: 23 nC

39. **(a)** $E = 0$; $V = 2.2 \times 10^{5}$ V
(b) $E = 4.3 \times 10^{5}$ N/C; $V = 0$
(c) When the two charges have the same sign, the electric fields at the midpoint have the same magnitude but opposite directions, so they cancel. The potential is the algebraic sum of the potentials due to the individual charges; it is a scalar and, in this case, adds to be greater than zero. When the signs are different, the electric fields point in the same direction and the magnitudes add. However, the potentials have opposite signs and cancel.

40. **(a)** 2.3 J **(b)** 1.2×10^{6} V **(c)** X

41. **(a)** 4.0×10^{5} V **(b)** R

Chapter 8

Practice Problems

1. **(a)** 3.0×10^{2} N/C[W]
(b) 3.0×10^{2} N/C[W]
(c) 3.0×10^{2} N/C[W]
(d) double the charge on each plate; halve the area of each plate

2. **(a)** 5.0×10^{3} N/C[E]
(b) The area of the plates was decreased by a factor of 4.

3. 8.0×10^{2} N[N]

4. 1.4×10^{3} N/C

5. **(a)** 3.0×10^{3} N/C
(b) 60.0 V

6. **(a)** 0.222 m
(b) 1.44×10^{-3} N[toward + plate]
(c) 1.44×10^{-3} N[toward + plate]

7. 26 V

8. **(a)** 4.0×10^{1} V **(b)** 2.0×10^{3} N/C

9. **(a)** 9.62×10^{-19} C **(b)** 6.00

10. **(a)** 3.7×10^{-15} kg **(b)** 3.6×10^{3} V

11. 1.13×10^{4} V

12. 1.4×10^{-13} N[toward the bottom of the page]

13. 2.7×10^{-14} N[left 28° up]

14. 30°

15. 9.8×10^{-3} T[N]

16. 4.2×10^{-3} T[up out of page]

17. 3.0×10^{2} N

18. 9.2×10^{-2} T[into the page]

19. 1.8 m

20. **(a)** 6.4×10^{2} A
(b) If such a large current could be passed through the wire, Earth's magnetic field could be used to levitate the wire. However, this is such a large current that it is probably not practical to do so.

21. **(a)** 2.884×10^{-17} J
(b) 1.86×10^{5} m/s

22. **(a)** up (that is, opposite to gravity)
(b) 59 V

23. **(a)** 1.4×10^{7} m/s
(b) 2.0×10^{6} V

24. 2.8×10^{-2} m

25. 6.8×10^{3} m/s

26. **(a)** 5.01×10^{-27} kg
(b) tritium

Chapter 8 Review

Problems for Understanding

22. 20 V

23. **(a)** 1.60×10^{2} V
(b) $V_A = 0.0$ V; $V_C = 8.0 \times 10^{1}$ V; $V_D = 1.2 \times 10^{2}$ V
(c) $V_B - V_A = 4.0 \times 10^{1}$ V; $V_C - V_B = 4.0 \times 10^{1}$ V; $V_D - V_A = 1.2 \times 10^{2}$ V
(d) 2.0×10^{3} N/C
(e) 2.0×10^{-3} N in both cases [toward negative plate]
(f) 4.0×10^{-3} N[toward negative plate]

24. **(a)** -8.0×10^{-19} C
(b) five electrons

25. 3.1×10^{10} electrons

26. 0.63 N

27. 3.2×10^{5} m/s

28. **(a)** 1.8×10^{-3} N[up]
(b) 0.18 g

29. 1.0×10^{-26} kg

30. **(a)** $r(\text{slow}) = 1.4 \times 10^{-4}$ m; $r(\text{fast}) = 2.8 \times 10^{-4}$ m
(b) $T(\text{slow}) = T(\text{fast}) = 8.9 \times 10^{-11}$ s
(c) $f(\text{slow}) = f(\text{fast}) = 1.1 \times 10^{10}$ Hz
(d) The period and frequency is independent of the particle's velocity and the radius of its orbit. The faster electron completes an orbit of larger radius in the same time in which the slower electron completes an orbit of smaller radius.

31. **(a)** $T_e/T_p = m_e/m_p = 5.4 \times 10^{-4}$
(b) $r_e/r_p = \sqrt{\frac{m_e}{m_p}} = 0.023$

32. **(a)** 3.0×10^{2} Hz; 6.3×10^{3} m
(b) 3.0×10^{2} Hz; 3.1×10^{3} m

33. **(a)** 1.1×10^{-17} T
(b) [E]

Unit 3 Review

Problems for Understanding

49. 1.8×10^{8} C

50. 8.23×10^{-8} N

51. 2.3×10^{-9} N

52. $\pm 14\ \mu$C

53. 1.5×10^{4} electrons

54. **(a)** -50.0 N **(b)** 5.56 N **(c)** 3.33 N **(d)** -3.70 N

55. $\pm 0.14\ \mu$C

56. 1.8×10^{13} C

57. -1.0×10^{4} C

58. 0.12 m

59. 8×10^{27} N

60. 9.2×10^{-26} N

61. 1.1×10^{-5} C

62. **(a)** 9 N
(b) An additional nuclear force — the strong force — holds the nucleus together.

63. 2000 N/C

64. 6.2×10^{12} electrons

65. **(a)** 0 J
(b) 8.6×10^{-10} J
(c) equipotential surfaces

66. (a) 4.8×10^{-19} C
(b) three electrons (deficit)
(c) 1.2×10^{4} V

67. 0.10 T

68. (a) 3.7 nC
(b) It will be reduced by one half.

69. (a) 2.2×10^{-13} N
(b) 1.3×10^{14} m/s^2[up]

70. 0.9 m

72. (a) 1.8×10^{-10} s (b) 2.8×10^{-4} m

73. 330 N/C

74. (a) $v_{\parallel} = 5.6 \times 10^{6}$ m/s; $v_{\perp} = 3.2 \times 10^{6}$ m/s
(b) 0.13 m
(c) 2.2×10^{-7} s
(d) 1.4 m
(e) From the side, a helical path will be seen; two places on consecutive orbits of the proton will be separated by 1.4 m. Face on, the orbit will appear to be circular, with a radius of 0.13 m.

75. 2.5 cm

Chapter 9

Practice Problems

1. 0.011 m
2. 1.3×10^{-5} m
3. red light will have a wider maximum; 7.3×10^{-3} m
4. (a) 0.36 m
(b) The value ignores changes in the speed of light due to the lenses of the imaging system and changes in the density of the atmosphere.
5. 0.00192°
6. Angular resolution improves with shorter wavelengths, so you should use blue lettering.

Chapter 9 Review

Problems for Understanding

31. (a) 0.020 m (b) 0.20 m/s

32. 4.8×10^{2} nm

33. 589 nm

34. 2.1×10^{-5} m

35. 3.0 km

36. 72 m

37. 485 nm; 658 nm

38. (a) 15° (b) decrease

39. sin θ will be greater than 1 for $\lambda > 629$ nm.

40. $\lambda_1/\lambda_2 = 3/2$

41. (a) 4th (b) 60°

42. 681 nm

43. 667 nm; red light

Chapter 10

Practice Problems

1. (a) 0.0667 s
(b) The distance that the signal passes is usually larger than the geographic separation between the two points (due to satellite networks); also, the speed of light depends on the medium.
2. 2.25×10^{8} m/s
3. (a) 46.8 m
(b) The antenna must be larger than the wavelength of the radiation.
4. (a) $\lambda_{micro} = 0.03$ m; $\lambda_{light} = 3 \times 10^{-6}$ m
(b) The metallic screen is used to stop the microwave radiation by working as an antenna for microwave wavelengths.

Chapter 10 Review

Problems for Understanding

35. 2.48×10^{-13} m

36. 1×10^{6} Hz or 1 MHz

37. 2.938 m; 102.1 MHz

38. (a) 0.80 J/s (c) 1/4
(b) 8.0×10^{-5} J/s

39. 8.3 light-minutes

40. 1.1×10^{4} m

41. 0.24 s

42. (a) Yes, but with very low frequency.
(b) Greater than 4×10^{14} Hz

Unit 4 Review

Problems for Understanding

50. 0.12 m; 2.5×10^{9} Hz; 4.0×10^{-10} s

51. 2.1×10^{5} Hz; 1.4×10^{3} m

52. 3×10^{-13} m

53. 5.4×10^{16}

54. 4.3×10^{-7} m = violet

55. 1.5×10^{2} m

56. 3.4×10^{-2} m

57. 9.4610×10^{15} m

58. Listeners in Vancouver will hear a particular sound after 1.7×10^{-2} s, while listeners in the back of the concert hall will hear the same sound after 0.24 s, so listeners in Vancouver will hear it first.

59. 585 nm

60. (a) 7.1 mm (b) closer

61. 1.2×10^{4} lines/cm

62. 8×10^{-7} m

63. (a) 0.42″ = 2.0×10^{-6} rad
(b) 0.0042″ = 2.0×10^{-8} rad
(c) 4.6×10^{12} m apart, or, it could distinguish objects that are 0.77 × Pluto's distance from the Sun apart
(d) better (resolution is proportional to wavelength)

64. 45 m

65. (a) 5.8×10^{-19} J (c) 9.0×10^{-20} J
(b) 1.3×10^{-17} J (d) 4.0×10^{-26} J

66. 2.26×10^{8} m/s

67. (a) 5.0×10^{-9} m (b) X ray

Chapter 11

Practice Problems

1. (a) 4.8×10^{-13} s (b) 1.5×10^{-13} s
2. 257 s
3. $0.94c = 2.8 \times 10^{8}$ m/s
4. 702 km
5. 0.31 m
6. (a) 1.74×10^{8} m/s
(b) The sphere's diameter appears contracted only in the direction parallel to the spacecraft's motion. Therefore, the sphere appears to be distorted.
7. 465 μg
8. 1.68×10^{-27} kg
9. $0.9987c = 2.994 \times 10^{8}$ m/s
10. 4.68×10^{-11} J
11. 1.01×10^{-10} J
12. 2.6×10^{8} m/s
13. 7.91×10^{-11} J
14. 1.64×10^{-13} J
15. 1.3×10^{9} J
16. 4.3×10^{9} kg/s

Chapter 11 Review

Problems for Understanding

18. 0.87c

19. (a) 3.2 m (c) 6.8×10^{-8} s
(b) 1.9 m

20. (a) 2.5×10^{-27} kg (b) 1.7×10^{-27} kg

21. plot

22. 3.0×10^{2} m/s

23. (a) c (c) c
(b) c

24. (a) 3.2 (c) 16 m
(b) 5.8×10^{-8} s

25. 1.2×10^{-30} kg, which is 1.3 times its rest mass

26. (a) 4.1×10^{-20} J **(b)** 4.1×10^{-16} J **(c)** 1.3×10^{-14} J **(d)** 5.0×10^{-13} J **(e)** (a) and (b)

27. $0.14c = 4.2 \times 10^{7}$ m/s

28. 3×10^{4} light bulbs

29. 4.8×10^{-30} kg; $m/m_o = 5.3$; $0.98c = 2.9 \times 10^{8}$ m/s

30. (a) 1.4 g **(b)** 29% or 0.40 g

Chapter 12

Practice Problems

1. 4.28×10^{-34} kg m/s
2. 9.44×10^{-22} kg m/s
3. 4.59×10^{-15} m
4. 3.66×10^{25} photons
5. 1.11×10^{10} Hz; radio
6. 1.05×10^{-13} m
7. 7.80×10^{-15} m
8. 1.04×10^{-32} m
9. 2.39×10^{-41} m
10. 5.77×10^{-12} m
11. 2.19×10^{6} m/s

Chapter 12 Review

Problems for Understanding

32. (a) 1.24×10^{15} Hz
(b) threshold frequency

33. (a) 2.900 eV **(b)** lithium

34. 1.5×10^{15} Hz

35. 2.2 eV

36. 5.8×10^{18} photons/s

37. (a) 1.2×10^{-27} kg m/s
(b) 1.3×10^{-27} kg m/s
(c) 9.92×10^{-26} kg m/s

38. 1.7×10^{17} Hz

39. 5.5×10^{-33} kg m/s

40. 7.0×10^{-27} kg

41. (a) 3.1×10^{-7} m
(b) 6.14×10^{-10} m
(c) 4.7×10^{-24} kg m/s

42. (a) 4.8×10^{-10} m **(b)** −1.5 eV

43. 486 nm

44. (a) 3.08×10^{15} Hz
(b) 97.3 nm
(c) -0.850 eV $= -1.36 \times 10^{-19}$ J
(d) 0.847 nm
(e) 487 nm

Chapter 13

Practice Problems

1. 0.060 660 00 u $= 1.0073 \times 10^{-28}$ kg
2. 1.237×10^{-12} J
3. 2.858×10^{-10} J
4. 2.6×10^{9} a
5. 3.5×10^{3} a
6. 8.49×10^{-8} mg
7. 0.141 68 u $= 2.3527 \times 10^{-28}$ kg; 2.114×10^{-11} J
8. 2.818×10^{-12} J
9. **(a)** 0.0265 u $= 4.40 \times 10^{-29}$ kg; 3.96×10^{-12} J
(b) 5.96×10^{11} J

Chapter 13 Review

Problems for Understanding

20. (a) $20p$, $20n$, $18e$
(b) $26p$, $30n$, $26e$
(c) $16p$, $18n$, $17e$

21. (a) 1.477×10^{-11} J
(b) 1.793×10^{-10} J

22. ${}^{230}_{90}\text{Th} \rightarrow {}^{4}_{2}\text{He} + {}^{226}_{88}\text{Ra}$

23. (a) 1/4 **(b)** 1/16 **(c)** 1/4096

24. (a) 4.876 MeV
(b) $v_{\text{He}} = 1.520 \times 10^{7}$ m/s; $v_{\text{Rn}} = 2.740 \times 10^{5}$ m/s
(c) 98%

25. 1.2×10^{-7} kg

26. 11.5 min

27. 1.2×10^{3} a

28. (a) 200
(b) 600
(c) 25
(d) 775
(e) ${}^{D}N(t) = {}^{P}N(0)(1 - (\frac{1}{2})^{t/T_{1/2}})$, where ${}^{D}N(t)$ is the number of daughter nuclei at any time, t, ${}^{P}N(0)$ is the number of parent nuclei at time, $t = 0$, and $T_{\frac{1}{2}}$ is the half-life of the parent nucleus.

29. (a) $R = 1/[2^{t/T_{1/2}} - 1]$ where R is the ratio of parent to daughter nuclei at any time.
(b) 4.25×10^{9} a; 3.89×10^{9} a; 2.93×10^{9} a
(c) Assuming that the samples were not polluted by having daughter nuclei present in the beginning, considering the large differences in ages, it is unlikely that these samples came from the same place.
(d) More than one half-life has elapsed.

30. 2.4×10^{-12} m (assuming the electron and positron are at rest initially)

31. (a) 3.56×10^{-13} J = 2.23 MeV
(b) $0.981c = 2.94 \times 10^{8}$ m/s
(c) The electron travels faster than the speed of light in water, which is 2.25×10^{8} m/s, and consequently emits Cherenkov radiation, a phenomenon analogous to a sonic boom.

32. (a) $udd \rightarrow uud + e^{-} + \bar{\nu}_e$ or $d \rightarrow u + e^{-} + \bar{\nu}_e$
(b) $\gamma + udd \rightarrow \bar{u}d + uud$

Unit 5 Review

Problems for Understanding

42. (a) $0.14c$ **(b)** $0.045c$

43. (a) 9×10^{16} J **(b)** 3×10^{7} a

44. (a) 3.1 light-year **(b)** 4.7 a **(c)** 6.3 a

45. (a) 1.1×10^{-13} J
(b) $1.3 \times$ rest mass energy
(c) 2.1×10^{-30} kg or $2.3 \times$ rest mass

46. (a) 3×10^{9} J **(b)** 4×10^{-8} kg

47. 1.12eV $= 1.80 \times 10^{-19}$ J

48. 4.7eV $= 7.5 \times 10^{-19}$ J

49. (a) 1.05×10^{15} Hz
(b) 287 nm

50. (a) 1.25 nm **(b)** 0.153 nm

51. (a) 2.47×10^{15} Hz
(b) 1.22×10^{-7} m
(c) Lyman

52. 486 nm

53. (a) 3.0×10^{-19} J
(b) 8.1×10^{17} photons

54. (a) 6.91×10^{14} Hz
(b) 4.34×10^{-7} m
(c) -0.544 eV $= -8.70 \times 10^{-20}$ J
(d) 1.32 nm
(e) 9.49×10^{-8} m
(f) UV

55. (a) 3.96×10^{-12} J/reaction
(b) 9.68×10^{37} reactions/s
(c) 6.64×10^{-27} kg/reaction
(d) 6.43×10^{11} kg/s
(e) 9.82×10^{9} a

56. (a) 4.40×10^{-29} kg
(b) 0.658%
(c) 1.18×10^{45} J
(d) 9.59×10^{9} a

57. 88.2 N

58. 1.9 GeV, 6.6×10^{-16} m